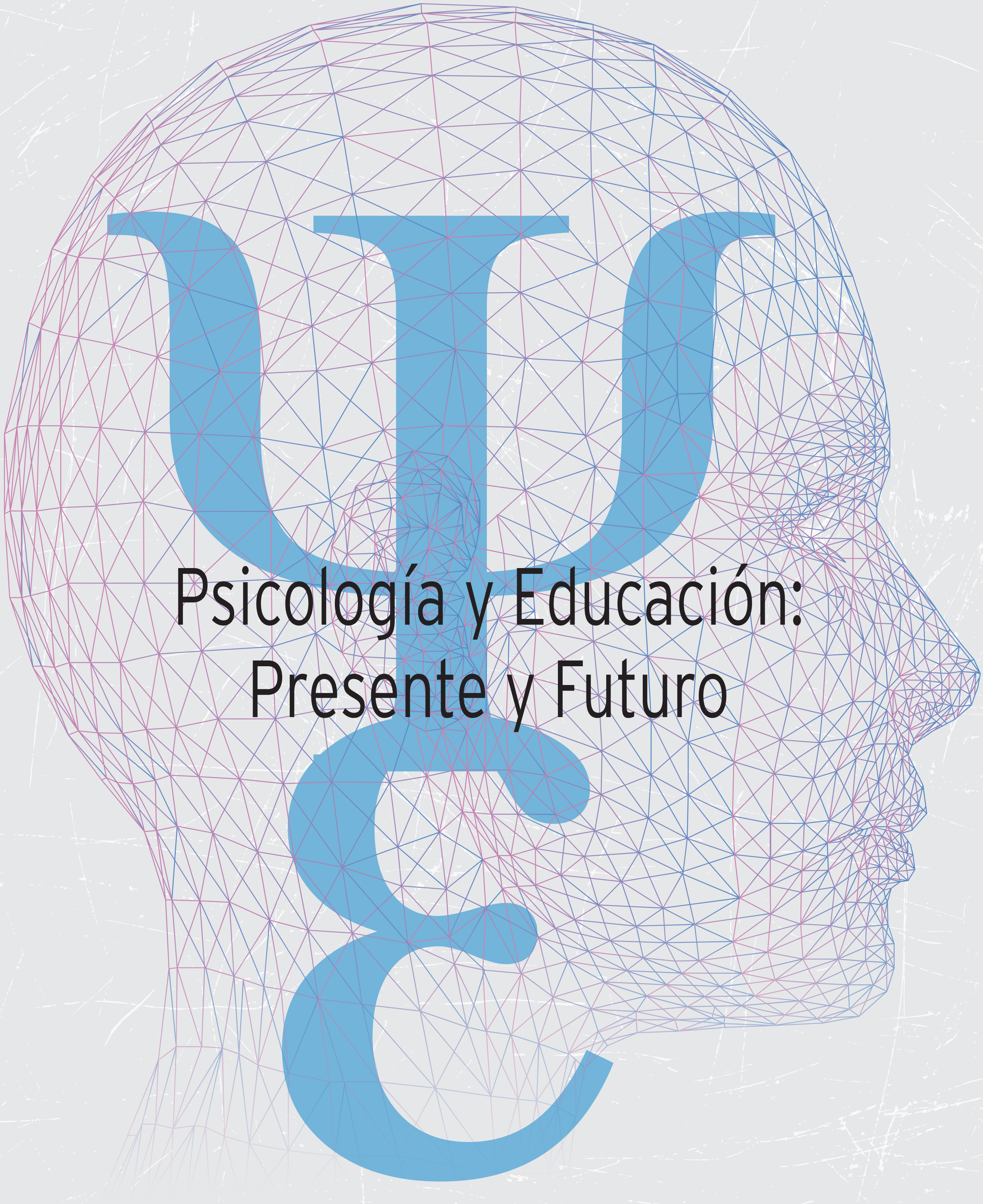

Psicología y Educación: Presente y Futuro

Coordinador: Juan Luis Castejón Costa

ACIPE- Asociación Científica de Psicología y Educación

Ediciones : ACIPE- Asociación Científica de Psicología y Educación

ISBN: 978-84-608-8714-0

The effect of explaining the meaning of formulas in homework tasks on 10th-grade students' test performance and their use of learning strategies

Ota, Eriko.

Graduate School of Education, The University of Tokyo, Tokyo, Japan

erikoota@p.u-tokyo.ac.jp

Abstract

In the last few decades, it has been proposed that deep processing (e.g., understanding and explaining the meaning of knowledge) is important for robust learning (i.e., long-term retention and transfer). Rosário et al. (2013) argued that the way teachers teach influences students' approaches to learning (i.e., deep or surface approach). However, compared to the effect of lessons, little is known about the effect of homework tasks on students' learning. This study addressed the question of wheter it is enough to focus on the use of deep approaches to learning only in lessons, or if we should also pay attention to homework design. Through a quasi-experiment, I examined the effect of homework tasks that prompted students to explain the meaning of mathematical formulas. In the treatment group, 10th-grade students (n = 42) were assigned explanatory tasks in all 10 lessons and in half of their homework tasks. In the control group, other students (n = 42) were not assigned explanatory tasks at all, but were instead assigned drill practice tasks as homework. About one month after the treatment, participants took a post-test that asked them to recall and explain the meaning of formulas and to solve some transfer problems. A mixed-design ANOVA revealed a main effect of the *Range* of questions (i.e., whether the explanatory homework was assigned or not in the treatment group) and a *Range* × *Group* interaction in the transfer problems. Post-hoc tests showed that the treatment group students scored significantly better in the questions of specific contents that they had explained twice through lessons AND homework. Moreover, the result of the students' questionnaire responses showed that the treatment group students used less surface strategies during the experiment. These results suggest the importance of carefully designing not only classroom lessons but also homework.

Key words: homework and lesson design; deep processing; understanding and explaining mathematical formulas; learning strategy use

1. Introduction

Many researches have shown problems of Japanese high school students' mathematics learning. For example, Fujimura (2012) analysed the results of PISA 2003 and found that Japanese students had a problem in explaining or transferring conceptual knowledge to cope with novel situations compared with remembering or applying procedural knowledge to solve typical problems. Fujisawa (2002) examined Japanese high school students' use of learning strategies and suggested that a large number of students had a tendency to memorize knowledge without understanding and to practice many times over without improving their way of learning.

1.1. Deep and Surface Approaches to Learning

These kinds of problems are related to research findings of *approaches to learning* (e.g., Marton and Säljö, 1976) and *learning strategy* (e.g., Mayer, 1980; Pintrich, Smith, García, and McKeachie, 1993). Many studies have shown the relationship between students' approaches to learning and their academic achievement (e.g., Cano & Berbén, 2009; Ichihara & Arai, 2006). Generally speaking, students who try to understand the meaning of learning material by relating it to prior knowledge, which indicates *deep approach*, can get better scores than those who learn contents without any comprehensive or integrative demands, which indicates *surface approach* (Rosário, Núñez, Ferrnando, Pavia, Lourenço, Cerezo, and Valle, 2013). Taking into account the situation of Japanese students mentioned above, it is important to consider how we can prompt them into understanding oriented learning style.

1.2. Effect of Homework Assignment

In order to approach the solution, it is a good way to consider the effect of teachers' instructions at school. Some research groups have examined the relationship between students' approaches to learning and teachers' approaches to teaching and found that there was clear relationship between them (e.g., Rosário et al., 2013). Among several kinds of instructional methods, homework assignment is one of the most controversial tools that seem to have some effect on students' approaches to learning (Cooper, 1994).

Large-scale investigations (e.g., Trautwein, Niggli, Schnyder, and Lüdtke, 2009) and meta-analysis of experiments (e.g., Cooper, Robinson, and Patall, 2006) have shown that homework assignment has both positive and negative effect on students' academic achievement and their learning behavior. For example, Stoeger and Ziegler (2008) conducted a classroom-based training and showed that trained teachers could prompt students into better learning strategy use (e.g., time-management). On the other hand, Trautwein et al. (2009) found that drill and practice assignments were associated with negative developments in homework effort and achievement. These results suggest that teachers should carefully consider the quality of homework assignment in order to make students become good learners.

However, previous studies have not clearly distinguished the effect of homework assignment from that of classroom lessons. Shinogaya (2010) pointed out that learning should be considered as the continuum of three phases (i.e., preparation, lesson, review) and that previous studies rarely paid attention to relationship between those phases. Classroom lessons might have influence on homework learning and vice versa. But most of the homework researches have focused on the simplex effect of homework itself and have not measured or manipulated the characteristics of preceding lessons.

1.3. Gap Between Classroom Lessons and Homework Tasks

The author conducted interview research in 2015. Eleven teachers who taught mathematics in Japanese schools participated in the interview, and were asked what kind of lessons and homework assignment they always did. Through the analysis of their answers, the author found that there was a large gap between the objectives of classroom lessons and that of homework assignment. Teachers often considered that it was important to make students understand the meaning of mathematical knowledge during lessons, but they barely assigned understanding-oriented tasks as homework. Some of them said that homework is a tool for practicing and students should concentrate on drill and practice while they are doing homework.

Yoshida and Murayama (2013) pointed out that students have a difficulty to use deep learning strategies because they often misunderstand which strategy is effective for their learning. Thus it is important for teachers to directly teach the effective learning skills, and homework might be a good way to do that. It is essential to clarify whether it is enough to focus on deep learning only in classroom lessons or there is an effect of homework tasks on students' approach to learning.

1.4. Hypothesis and Overview of the Experiment

The main hypothesis investigated in the present study was that explaining the meaning of formulas in homework tasks would improve students' test performance and their use of understanding-oriented learning strategies. It was also hypothesized that even if teachers made an opportunity for students to explain the meaning of formulas during classroom lessons, students would get better scores when assigned explanatory homework than when assigned drill practice one.

This study focused on the activity of explanation, because many studies have shown that explaining learning material is a good way to deeply understand the knowledge (e.g., Chi, Bassok, Lewis, Reimann, & Glaser, 1989). Note that explanation is just one way of effective deep learning methods.

To test the hypotheses, two conditions were prepared: the first was a condition in which students were assigned only drill practice homework (control group), and the second was a condition in which students were assigned explanatory homework tasks and they could also practice explaining the meaning of formulas with their classmates during classroom lessons (treatment group). In the second condition, explanatory homework was assigned only in half of the total lessons so that we can assess the effect of homework task quality within participants and the effect of lessons between groups.

It was predicted that treatment group would get better score than control group when drill practice was assigned as homework because of the effect of peer explanation during lessons (Hypothesis 1), and even within the treatment condition students get better score when explanatory tasks were assigned as homework (Hypothesis 2). And during the homework intervention, treatment group students would become to use more understanding oriented leaning strategies and less memorizing-repetition strategies (Hypothesis 3).

2. Method

2.1. Participants

Participants were 10th grade students from two classes of a high school in an urban Japanese city. Each of the classes had forty-two students and was taught mathematics by different teachers. All of the students were male, because the high school was a school for boys. At the beginning of this study, only one class (which was assigned to treatment group) was planned to participate. Afterward, another class (assigned to control group) joined in the study because the class teacher took an interest in this experiment.

2.2. Design

A two-group quasi-experiment was conducted to assess the effectiveness of explanatory homework tasks on students' test performance and their learning strategy use. Because the study plan has changed during the experiment, the design is a little complicated (See Figure 1).

Independent Variables: Groups and Interventions

The study consisted of two groups: treatment group and control group. The pre-existing classes were assigned to each group. In both conditions, participants attended 10 lessons for about 1 month. Topic of the lessons was about trigonometric ratio. Between the conditions, there were 2 points of differences about the intervention: (1) homework tasks and (2) classroom lessons.

(1) Homework tasks*:* In the treatment condition, students were assigned explanatory tasks as homework in half of 10 lessons. In contrast, control group students were assigned only drill practice tasks every 10 times after the lessons.

(2) Classroom lessons: In order to test wheter it is enough to focus on deep learning only in lessons or not, this study also manipulated classroom lessons. Treatment group students worked on peer explanation every times after listening to teacher's lecture. On the other hand, the teacher in control group did not make any opportunity for students to explain the knowledge they learned.

Dependent Variables

(1) Test performance: In order to test the effect of explanatory homework on students' academic achievement, this study consisted of a 2 × 2 factorial design that crossed *the range of questions* (contents A or B in Figure 1, which indicates whether the explanatory homework tasks were assigned or not in treatment group) and *group* (treatment or control). *The range of questions* was within-subject factor, and *group* was between-subject factor. Note that the explanatory homework was not assigned to control group. Thus *the range of questions* in-control group was analyzed to check the difference of task difficulty.

(2) Learning strategy use: In order to test the effect of explanatory homework on students' learning strategy use, the study was designed to measure the change of learning strategy use within participants. Students in treatment group reported their learning strategy use three times: 1 week before the intervention (T1), 3 days after the intervention (T2), 1 month after the intervention (T3). Between T2 and T3, treatment group students kept peer-explanation during lessons, but homework-task intervention disappeared.

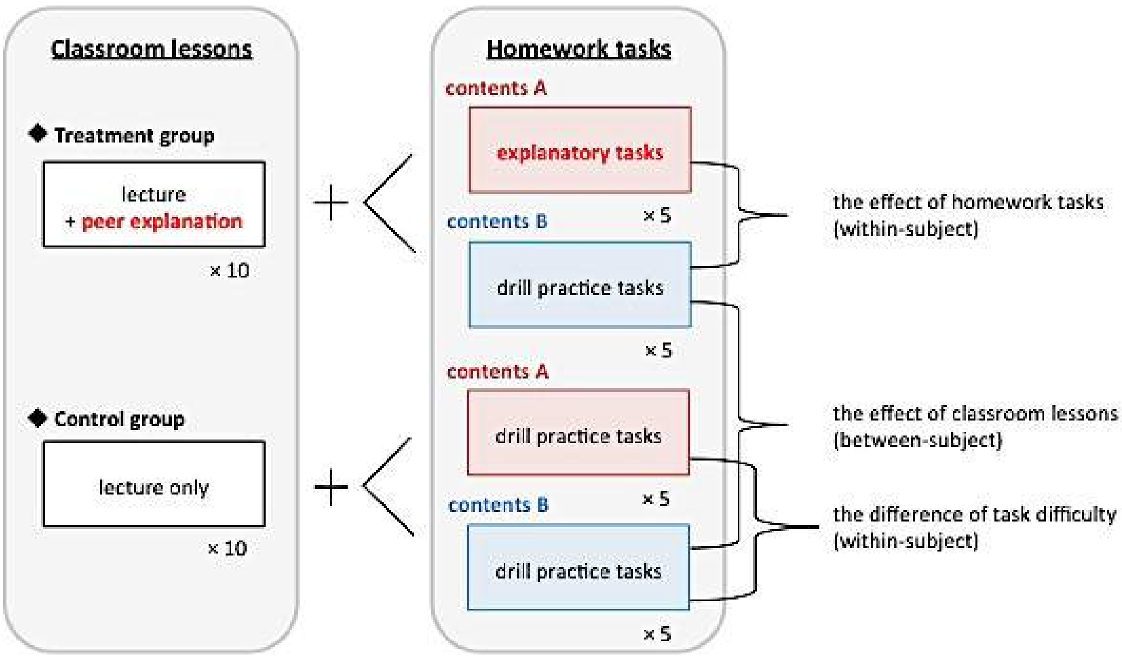

Figure 1
Design of This Study

2.3. Procedure

This experiment was conducted in the actual school environment. Before the intervention, the author discussed the lesson plan and made explanatory homework tasks with the teacher who taught in treatment group. During the treatment, explanatory homework were handed in every 2 or 3 days after the assignment, and they were returned to students along with model answers in 1 or 2 days. Drill practice homework was not handed in during the treatment, but after the intervention students reported what time did they practice each problem, which was a habitual way of evaluation at the school. The post-test was administered to both groups 1 month after the intervention. In addition to the post-test, treatment group students were asked to report their learning strategy use 3 times before and after the intervention (T1, T2, T3).

2.4. Materials

Classroom Lessons

In each lesson of the both classes, teachers gave a lecture on formulas of trigonometric ratio (e.g.,). The lecture mainly explained "why the formulas hold" and "how the formulas can be used to solve problems." In the treatment group lessons, students explained each other "why the formula holds" by using diagrams or graphs like their teacher did during the lecture.

Homework Tasks

(1) Explanatory tasks*:* This type of tasks asked students to explain and write down why a certain formula holds in their own words (e.g., "Explain why '' holds"; See Figure 2). These were almost the same tasks as they had done during the preceding lessons.

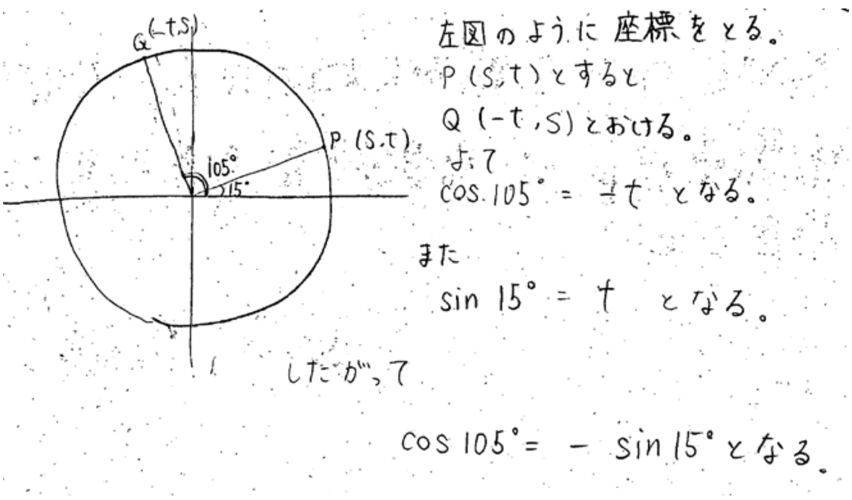

Figure 2
Example for the Explanatory Homework Task

(2) Drill practice tasks*:* This type of tasks was the typical homework in the cooperated high school. All students in that school had a workbook called "CLEAR MATHEMATICS", which conformed to the official textbook. Using this workbook, students could practice problem solving. However, in order to solve the problems, it was just enough to remember the formulas and students did not have to deeply understand the meaning of knowledge (e.g., "Represent by using trigonometric ratio under ").

Post Test

This was administered to find out how well students can solve problems and transfer the knowledge to novel situations. Two types of problems were used in the assessment.

(1) Basic problem solving tasks: These were similar with the drill practice tasks assigned as homework during the intervention. Students had to remember the formulas and apply them to solve problems.

(2) Transfer tasks: These were novel problems for students (They didn't directly learn the way of solving). In order to solve them, students had to deeply understand the meaning of formulas they learned and transfer the knowledge to the novel situations (e.g., "These are the definition of . Represent by using trigonometric ratio under .").

Learning Strategy Use

This was administered by the questionnaire (Ichihara & Arai, 2006). The learning strategy measure used in this study consisted of 12 items; 7 items indicated *understanding oriented strategies* (e.g., "When studying formulas or principles, I don't only memorize them but also try to consider why they can hold."), and 5 items indicated *memorizing-repetition strategies* (e.g., "I repeatedly practice the same math problems.").

3. Results

When conducting analyses, participants who were absent from the post-test were excluded. The mean number of participants who failed to hand in the explanatory homework was 2 per day, and there were only 2 students who failed to hand in the homework twice. Thus the author didn't exclude participants any more. The final numbers of participants included in the analyses were 40 in treatment group and 41 in control group.

3.1. Test Performance

To examine Hypothesis 1 and Hypothesis 2, the test scores were analyzed with a 2 × 2 mixed ANOVA, with *the range of questions* (contents A/contents B) as the within-participants factor and *group* (treatment/control) as the between-participants factor.

(1) Basic problem solving tasks: As the result of ANOVA, the main effect of *the range of questions* was significant ($F_{(1, 79)} = 19.87$, $p < .001$). However, both the effect of *group* ($F_{(1, 79)} = 0.90$, n.s.), and the interaction between the two variables ($F_{(1, 79)} = 0.01$, n.s.), were not significant. This finding suggests that there was only a difference of task difficulty between the contents, and both the lessons and the homework tasks had no effect on the performance of basic problem solving (Hypothesis 1 and 2 were not supported). Results were shown in Figure 3.

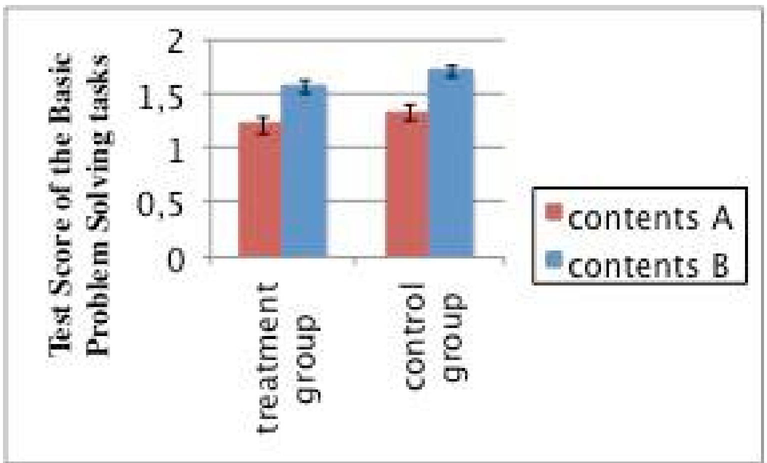

Figure 3
Mean scores of the basic problem solving tasks in treatment and control group. Error bars are standard errors of each mean.

(2) Transfer tasks: As the result of ANOVA, the main effect of *the range of questions* ($F_{(1, 79)} = 12.69$, $p < .001$)

and the interaction between the two variables ($F_{(1, 79)} = 4.69$, $p < .05$) were significant. However, the main effect of *group* was not significant ($F_{(1, 79)} = 0.26$, n.s.). Analysis of simple main effects confirmed that treatment group students got better score than control group at contents A ($F_{(1, 79)} = 3.81$, $p < .10$) and the score of contents A was higher than that of contents B at treatment group ($F_{(1, 79)} = 18.35$, $p < .001$). On the other hand, the score gap between contents A and B at control group ($F_{(1, 79)} = 0.89$, n.s.) and the gap between treatment and control group at contents B ($F_{(1, 79)} = 1.00$, n.s.) were not significant. These results suggest that there was no difference of task difficulty between the contents, and that the classroom lessons had no effect on transfer (Hypothesis 1 was not supported). And they also suggest that assigning the explanatory homework tasks had some effect on students' test performance of transfer tasks (Hypothesis 2 was supported). Results were shown in Figure 4.

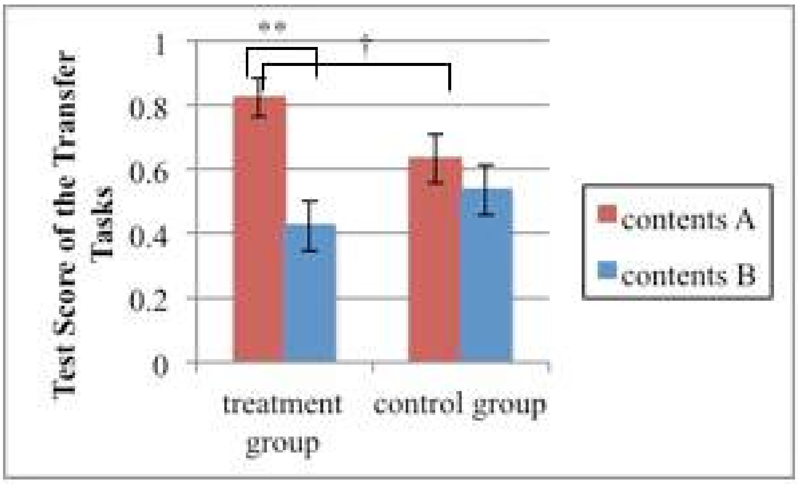

Figure 4
Mean scores of the transfer tasks in treatment and control group. Error bars are standard errors of each mean. †: $p < .10$, ***: $p < .001$.

3.2. Learning Strategy Use

To examine Hypothesis 3, repeated measures analysis of variance, for the effect of *time* (T1/T2/T3), was conducted on the scores of learning strategy use which was self-reported by treatment group students. Comparing the mean scores of understanding oriented strategies, the ANOVA revealed no main effect for *time* ($F_{(2, 76)} = 0.27$, n.s.). In contrast, comparing the mean scores of memorizing-repetition strategies yielded significant differences for *time*, $F_{(2, 70)} = 4.99$, $p < .01$. Post hoc comparisons confirmed that the score of memorizing-repetition strategies at T2 was significantly lower than that of T1 ($t = 4.16$, $p < .001$). This result suggests that participants in treatment group used less surface approach to learning during the intervention (Hypothesis 3 was partly supported). Results were shown in Figure 5.

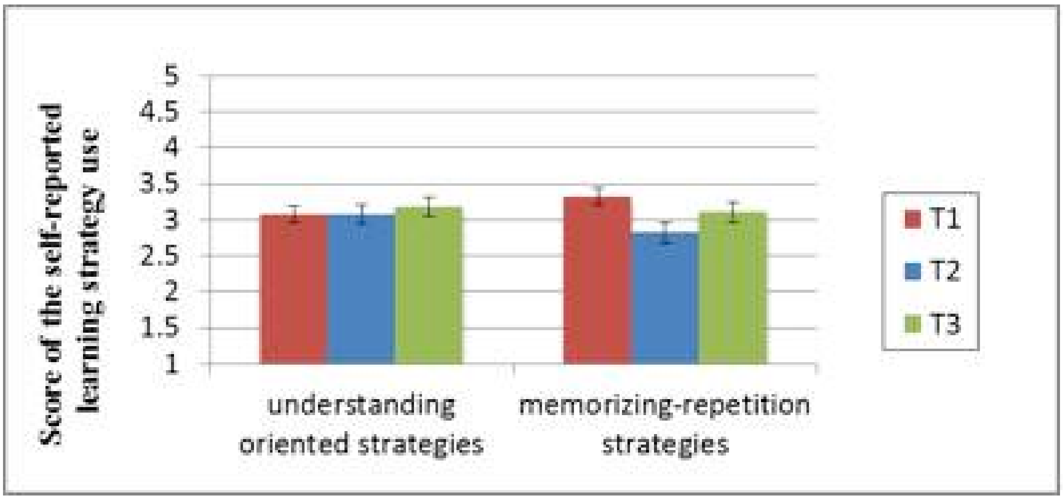

Figure 5
Mean scores of the self-reported learning strategy use. Error bars are standard errors of each mean. ****: $p < .001$.*

4. Discussion

The main purpose of this study was to examine whether explaining the meaning of formulas in homework tasks improves students' test performance and their learning strategy use. The present study showed that peer explanation during classroom lessons itself had no effect on students' test performance (Hypothesis 1 was not supported), but that students got significantly better scores on transfer tasks when the explanatory homework was combined with lessons (Hypothesis 2 was supported). And the study also suggested that participants in treatment group used less memorizing-repetition strategies during the intervention, although their use of understanding oriented strategies did not significantly change (Hypothesis 3 was partly supported).

When interpreting the results of the present study, readers should bear several caveats in mind. First, because the participants of this study were only males, we need further research to generalize the results of this study to females. Second, we carried out the intervention only for about 1 month. That might be too short to improve students' performance and use of learning strategies. Third, the measurement of learning strategy use was based on the students' self-report. It is known that answers to questionnaires are often biased, thus we need to measure not only item responses but also actual learning behaviors. Fourth, the design of this study was quasi-experiment, thus we could not control the effect of classes. More rigorous experiment based on a randomized assignment is needed.

Acknowledgements: The author is grateful to the teachers and students who participated in this experiment, and to professor Dr. Shinichi Ichikawa, Dr. Emmanuel Manalo and Dr. Yuri Uesaka for helpful discissions and a lot of advices.

References

Cano, F., & Berbén, A. B. G. (2009). University students' achievement goals and approaches to learning in mathematics. *British Journal of Educational Psychology*, *79*(1), 131-153.

Chi, M. T., Bassok, M., Lewis, M. W., Reimann, P., & Glaser, R. (1989). Self-explanations: How students study and use examples in learning to solve problems. *Cognitive science*, *13*(2), 145-182.

Cooper, H. (1994). *The Battle over Homework. An Administrator's Guide to Setting Sound and Effective Policies. The Practicing Administrator's Leadership Series*. Corwin Press, Inc., 2455 Teller Road, Thousand Oaks, CA 91320-2218.

Cooper, H., Robinson, J. C., & Patall, E. A. (2006). Does homework improve academic achievement? A synthesis of research, 1987–2003. *Review of educational research*, *76*(1), 1-62.

Fujimura, N. (2012). 'Suugakuteki kagakuteki riterashi no shinrigaku: Kodomo no gakuryoku ha dou takamaruka'[Psychology of mathematical and scientific literacy: How do children improve their learning]. *Yuhikaku*.

Fujisawa, S. (2002). 'Gomakasi benkyo (zyo) Gakuryoku teika wo zyotyosuru sisutemu'[Inappropriate learning style: The system which encouraging depression of academic levels]. *Shinyosya.*

Ichihara, M, & Arai, K. (2006). Moderator effects of Meta-cognition: A test in math of a motivational model. *The Japanese Journal of Educational Psychology*, *54*(2), 199-210.

Marton, F., & Säljö, R. (1976). On qualitative differences in learning: I—Outcome and process*. *British journal of educational psychology*, *46*(1), 4-11.

Mayer, R. E. (1980). Elaboration techniques that increase the meaningfulness of technical text: An experimental test of the learning strategy hypothesis. *Journal of Educational Psychology*, *72*(6), 770.

Pintrich, P. R., Smith, D. A., García, T., & McKeachie, W. J. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and psychological measurement*, *53*(3), 801-813.

Rosário, P., Núñez, J. C., Ferrando, P. J., Paiva, M. O., Lourenço, A., Cerezo, R., & Valle, A. (2013). The relationship between approaches to teaching and approaches to studying: A two-level structural equation model for biology achievement in high school. *Metacognition and learning*, *8*(1), 47-77.

Shinogaya, K. (2010). Learning strategies: A review from the perspective of the relation between learning phases. *The Japanese Journal of Educational Psychology*, *60*(1), 92-105.

Stoeger, H., & Ziegler, A. (2008). Evaluation of a classroom based training to improve self-regulation in time management tasks during homework activities with fourth graders. *Metacognition and Learning*, *3*(3), 207-230.

Trautwein, U., Niggli, A., Schnyder, I., & Lüdtke, O. (2009). Between-teacher differences in homework assignments and the development of students' homework effort, homework emotions, and achievement. *Journal of Educational Psychology*, *101*(1), 176-189.

Yoshida, T., & Murayama, K. (2013). Why do students often fail to use learning strategies that experts have found effective? An intra-individual analysis. *The Japanese Journal of Educational Psychology*, *61*(1), 32-43.